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ABSTRACT

The oxygen profile procedure is a means of measuring the oxygen concentration at various locations in a basin. By dividing the surface of a basin into sections and then establishing sample points on the surface, at mid-depth, and near the bottom, a waste water treatment plant operator can measure and plot dissolved oxygen data which can be plotted to visually show oxygen concentrations throughout the basin. Designed for individuals who have completed National Pollutant Discharge Elimination System (NPDES) level 1 laboratory training skills, this module provides operators with the basic skills and information needed to: (1) successfully run the oxygen profile test; (2) record data; (3) graph results; (4) interpret information in terms of recognizing areas of oxygen deficiency in the system being tested; and (5) obtain reliable, consistent results. The instructor's manual contains a statement of instructional goals, lists of instructor/student activities and instructional materials, narrative of the slide/tape program used with the module, overhead transparency masters, and student worksheet (with answers). The student workbook contains objectives, prerequisite skills needed before the module is started, laboratory procedures, and worksheet. (Author/JN)

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Operational Control Tests

for Wastewater Treatment Facilities

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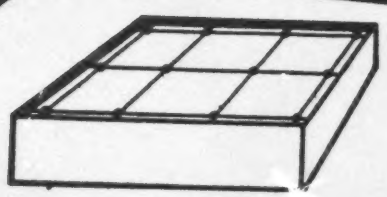
Oxygen Profile

Instructor's Manual



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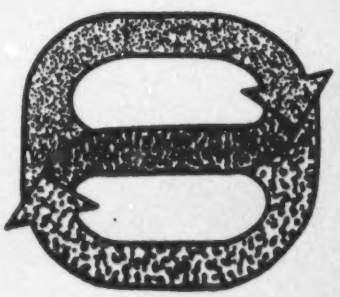

Linn-Benton Community College
Albany, Oregon

OXYGEN PROFILE

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OXYGEN PROFILE

CONTENTS

Subject	Page
Instructional Goals	Op-1
Instructor Activities	Op-1
Student Activities	Op-2
Instructional Materials List	Op-2
Narrative	Op-3
Appendix A	
Plotting Oxygen Profile Data	Op-7
Overheads 1 - 3	
Answers to Worksheet	W-Op-1
Student Materials	S-Op-1 thru 8
	SW-Op-1 thru 3

INSTRUCTIONAL GOALS

Upon completion of this module the student should be able to successfully run the oxygen profile test, record the data, graph the results, and interpret the information in terms of recognizing areas of oxygen deficiency in the system being tested.

INSTRUCTOR ACTIVITIES

The following sequence is recommended for best use of this material:

Activity	Time
1. Review objectives with students.	5 minutes
2. Have students read through the procedure.	10 minutes
3. View and listen to the slide/tape program.	14 minutes
4. Discussion.	15 minutes
5. Demonstrate the test procedure.	20 minutes
6. Assign the worksheet.	5 minutes
7. Correct the worksheet.	60 minutes

OTHER ACTIVITIES

The above sequence should be followed if there is time. If time is short and if the students have prior experience in laboratory procedures the demonstration may be omitted. Items to emphasize during the demonstration should include:

1. Calibration of DO meter, including check of membrane.
2. Method of reaching sample site; boat vs. clothesline apparatus.
3. Plotting of DO concentration vs. depth at each sample point; emphasize accurate recordkeeping.
4. Discuss various ways to illustrate plotting data.

Appendix A can be used to discuss several ways to illustrate data.

STUDENT ACTIVITIES

1. Read objectives.
2. Read procedures.
3. View the slide program.
4. Complete worksheet.
5. Perform test.
6. Record data.

INSTRUCTIONAL MATERIALS LIST

1. Instructor's Guide for Oxygen Profile
2. Student Workbook for Oxygen Profile
3. 35 mm projector
4. Cassette tape player with automatic synchronization
5. Projector screen
6. Overhead projector
7. Equipment listed in the lab procedure for dissolved oxygen

OXYGEN PROFILE

NARRATIVE

Slide #

1. This lesson on the Oyxgen Profile Test covers the theory, the equipment, the procedure, and the application of the test.

2. The lesson was written by Mr. John F. Wooley and Dr. John W. Carnegie. Instructional development was done by Priscilla Hardin. Dr. Carnegie was the project manager.

3. Most aquatic organisms use DO or dissolved oxygen as they consume organic materials. The amount of dissolved oxygen present is one of the limiting factors which controls how fast and how much they consume.

4. Dissolved oxygen may be present in varying amounts. The aerobic zone has high to moderate levels of DO. The anaerobic zone may have very little or no DO.

5. Organisms in wastewater systems have optimum DO ranges in which they function most efficiently. The aerobic organisms function most efficiently at moderate DO concentration. At low DO concentration aerobic organisms may not flourish, and in fact septic conditions may develop. At high DO ranges the aerobic forms may undergo stresses not desirable in biological treatment processes.

6. Mixing distributes DO throughout a basin. If the basin is not mixed the organisms and food sink to the bottom of the basin. This results in major DO consumption at the bottom of the tank.

7. However, if the basin is well mixed, oxygen is distributed thorughout the basin. Aeration equipment in biological treatment systems provides both oxygen and mixing.

8. Aeration equipment may not provide complete mixing. Areas may develop where there is a low DO level and eventually become septic.

9. An oxygen profile is made to find out what the DO concentrations are at all points in the basin. Operators use the oxygen profile to identify problems caused by poor DO distribution.

10. Dead spots caused by inefficient mixing and faulty aerators can be located in activated sludge aeration basins, oxidation ditches, aerobic digesters and aerated lagoons. DO conditions in facultative ponds can also be analyzed.

11. The oxygen profile analysis is a series of DO measurements performed at sample points throughout the basin. Measurements are made near the surface, near the bottom, and in the middle.

12. The only analytical equipment necessary for the oxygen profile analysis is a DO meter with a weighted 50 foot lead.

13. Some device to reach the center of the basin is needed. A clothesline suspension system or a small boat could be used. If a boat is used it should have adequate stability and provide for safe operation. Either method must provide for DO probe positioning at various depths and at different surface sites.

14. The oxygen profile determination includes 4 components: The selection of sample points, taking the DO measurements, recording the data, and plotting the profiles. Let's look at each of these components in detail.

15. The objective of the oxygen profile determination is to completely map the basin's DO concentration. Therefore, sample points should be established to cover the entire basin. That is, the oxygen level at all corners as well as the center must be measured.

16. Sample points are most easily selected by considering the basin to be a regular geometric shape and dividing the surface into sections which give systematically distributed sample sites. Usually a pattern of surface sample sites near the edges and some in the middle will result.

17. DO measurements are made at different depths directly below the sample sites. It is easy to see how the entire basin is covered when the DO at the three depths below each sample site is measured.

18. Whatever the geometric shape, a similar process can be used to established the sample points. Remember, select sample points to provide DO measurements throughout the entire basin.

19. A sample point labeling scheme should be developed. For example, each site on the surface grid could have a number say, 1 thru 9.

20. To identify the sample points beneath each site, use letters. A could indicate the top point, B the middle point, and C the lower point. Thus, 3-B would be at site 3 on the surface grid and at the middle depth.

21. After establishing the sample points we can prepare to make the DO measurements. First standardize the DO meter.

22. Then, using the small boat or the suspension device position the DO probe over the sample site. Readings should be made just below the surface, at mid-depth, and about a foot off the bottom. Lower the probe to the designated depth and observe the DO reading on the meter.

23. Be sure to use a data sheet that clearly indicates the sample point from which each reading is taken. Take care to record the data in the correct spaces provided.

24. Now let's consider two of the several methods that could be used to plot the DO profiles.

25. A basin could be visualized as having three cross-sections created by sample sites one, two, three, four, five, six, seven, eight, and nine, respectively.

26. For cross-section one, two, three, each sampling site has three sample points or nine DO values. Write in the mg/l DO at each of the sample points. By comparing the values on each cross-section the DO pattern in the basin can be determined.

27. Another method using the cross-section idea would be to graph the DO data on each cross-section. Plot below the sample site the DO measured at each depth and then connect these points. This provides a visual display of the DO pattern in the basin.

28. A seperate page of graph paper should be used for each cross-section so that a family of oxygen profiles results for the basin. Any method of plotting the data that makes it easy to visualize the DO condition throughout the basin is acceptable. Choose the methods that fit your needs and with which you are the most comfortable.

29. In this lesson we have looked at the equipment necessary to gather data for the DO profiles.

30. We have discussed how basins can be divided to establish sampling sites and we have seen how the sampling sites are used to establish sampling points at three different depths.

31. After DO concentrations were measured they were recorded on an appropriate data sheet.

32. And finally, the data was plotted to indicate oxygen profiles within the basin.

33. The DO profile can be a valuable operational tool. It can be of value in operations of any biological treatment process utilizing an aeration basin of some type.

34. Clues such as dark color, foul odor, and uneven mixing patterns, as well as results from other lab analysis can indicate DO distribution problems.

35. The oxygen profile determination can be used to varify and locate the source of DO distribution problems indicated by other observations and operational tests.

36. The oxygen profile should be run at times when flow and loading are at a maximum. This allows an evaluation under the most severe conditions. It may also be of value to run suspended solids on samples taken at the same points so as to develop a parallel solids profile.

37. Proper balance between oxygen level and feed rate can be determined using the oxygen profile.

38. The oxygen profile can be used as a tool to help operators maintain proper DO balance throughout the basin. Since oxygen demand is different in various parts of the basin, proper DO balance is critical to good activated sludge operation.

39. An abnormally high BOD or oxygen uptake rate in the aeration basin effluent may indicate inadequate oxygen supply or insufficient aeration detention time. The oxygen profile will help evaluate this condition.

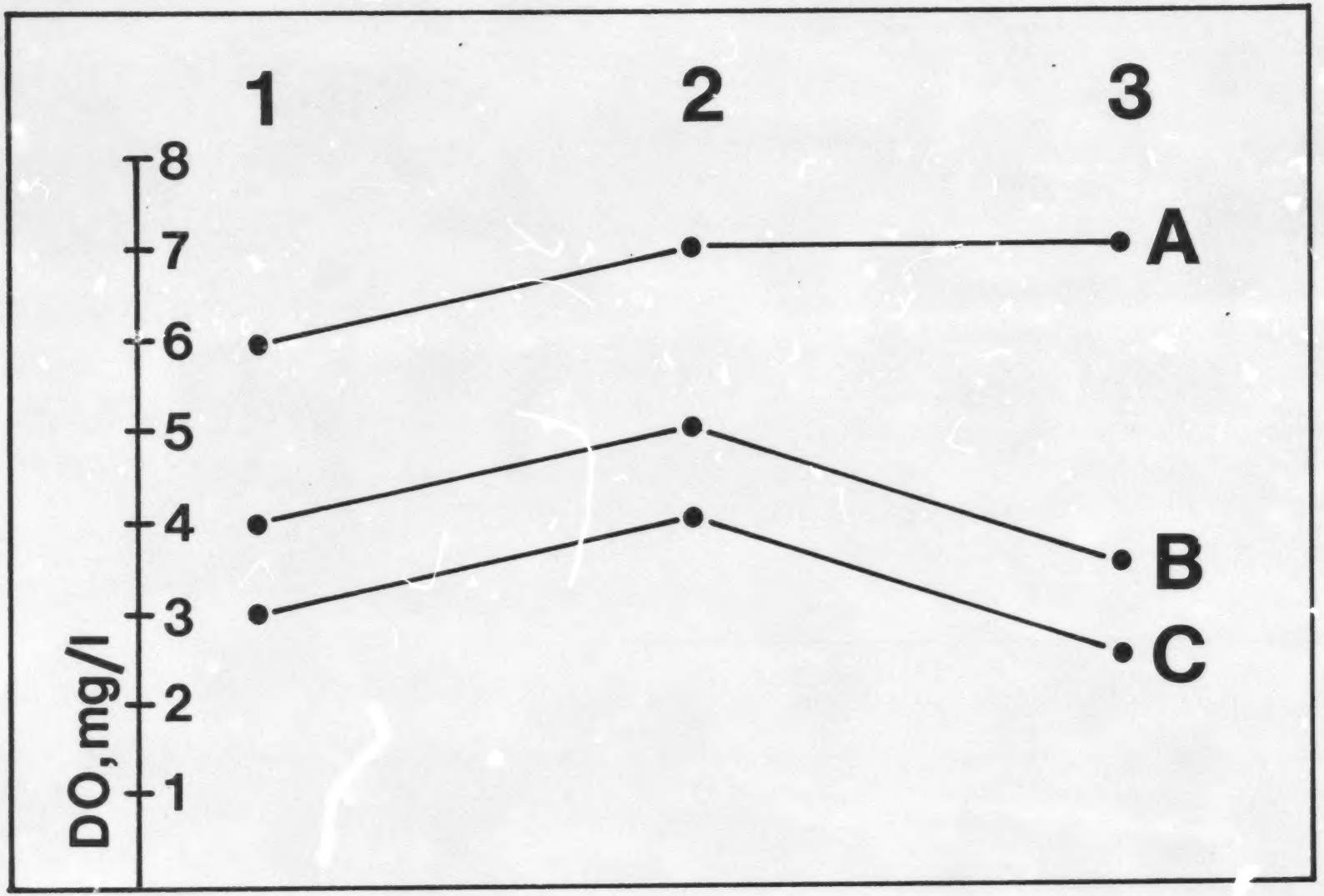
40. Excessive DO levels can lead to over-oxidized sludge or nitrification. Oxygen profile determination can also help identify these conditions.

41. Loading conditions can be evaluated in facultative ponds by using by using DO profiles.

42. In summary, oxygen profile mapping is a valuable tool for efficient operation. It can and should be utilized to help evaluate any problems relating to oxygen supply and distribution in an aerobic biological system.

1
2
3
A
B
C

	1	2	3
A	6.0	7.0	7.0
B	4.0	5.0	3.5
C	3.0	4.0	2.5


1
2
3
8
7
6
5
4
3
2
1
DO,mg/l
A
B
C

OXYGEN PROFILE TEST

WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. Most aquatic organisms use _____ as they convert food to stabilized end products.

   a)_____ nitrogen
   b)_____ carbon dioxide
   c)__X__ dissolved oxygen
   d)_____ methane
   e)_____ hydrogen

2. If water lacks _____ the organisms and organic materials sink to the bottom of the basin.

   a)_____ carbon dioxide
   b)__X__ turbulence
   c)_____ oxygen
   d)_____ organisms
   e)_____ solids

3. Aeration equipment in biological treatment systems provide _____.

   a)_____ organisms and solids
   b)_____ organics and inorganics
   c)_____ food and energy
   d)__X__ oxygen and mixing
   e)_____ nitrogen and phosphates

4. In order to find out if appropriate DO concentrations exist in a basin an _____ is made.

   a)_____ MLVSS test
   b)_____ pH test
   c)__X__ oxygen profile test
   d)_____ spin test
   e)_____ solids test

5. The oxygen profile analysis is a series of _____ measurements performed at preselected sample points in an aquatic system.

a)_____ pH tests
b)_____ solids tests
c)_____ spin tests
d)_____ CO_2 tests
e)__X__ oxygen

6. Measurements are made throughout the basin near _____.

a)__X__ the surface, middle and bottom
b)_____ the endline
c)_____ the aerators
d)_____ the cat walk
e)_____ the pumps

7. Equipment necessary for the oxygen profile analysis includes:

a)__X__ DO meter with 50 foot lead
b)_____ pH meter and conductivity meter
c)_____ DO meter and centrifuge
d)_____ balance and burette
e)_____ thermometer and pH meter

8. The oxygen profile test includes four components. These components are:

a)_____ pH reading, centrifuge spin, sample collection, and alkalinity determination.
b)__X__ establishment of sample points, making measurements, recording data, and plotting data.
c)_____ temperature measurements, pH measurements, conductivity measurements, calculations of raw data.
d)_____ sample collection, sample analysis, plotting of data, calculations.
e)_____ None of the above.

9. The most obvious application of the oxygen profile determination is to varify and locate the source of _____ problems in the basin.

a)_____ pH

b)_____ alkalinity

c)_____ solids concentration

d)__X__ aeration

e)_____ temperature

10. The oxygen profile can be used as a tool to help adjust _____ to achieve the proper balance.

a)_____ pH

b)_____ temperature

c)_____ alkalinity

d)_____ CO_2

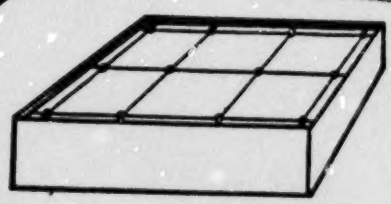
e)__X__ aeration rate

Operational Control Tests

for Wastewater Treatment Facilities

Oxygen Profile

Student Workbook



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OXYGEN PROFILE

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OXYGEN PROFILE

CONTENTS

Subject	Page
Introduction	S-Op-1
Objectives	S-Op-1
Prerequisite Skills	S-Op-1
Resource List	S-Op-1
Oxygen Profile Procedure	S-Op-2
Oxygen Profile Data Sheet	S-Op-6
Sample Data Sheet	S-Op-7
Procedure Summary	S-Op-8
Worksheet	SW-Op-1

INTRODUCTION

This lesson on the Oxygen Profile Test is intended to give the operator the basic information necessary to obtain reliable, consistant results. The mention of any brand names should not be taken as an endorsement of that equipment.

This test procedure is intended to be used by individuals who have completed NPDES Level I laboratory skills training.

OBJECTIVES

Upon completion of this module you should be able to:

1. Describe the purposes of the oxygen profile test.
2. Describe the sample site selection process.
3. Describe the oxygen profile test.
4. Accurately record oxygen data.
5. Graphically show the profile of oxygen concentrations throughout a basin.
6. Perform the test procedure.

PREREQUISITE SKILLS

In addition to the skills listed in the introduction, the following skills are needed for this test:

1. Ability to use a sounding line.
2. Ability to use a DO meter.

RESOURCE LIST

Laboratory Manual for Water and Wastewater, Part I Basic, Carnegie, J.W., and Wooley, J., Linn-Benton Community College, Albany, Oregon, 1979.

OXYGEN PROFILE PROCEDURE

INTRODUCTION

The oxygen profile procedure is a means of measuring the oxygen concentration at various locations in a basin. By dividing the surface of a basin into sections and then establishing sample points on the surface, at mid-depth, and near the bottom an operator can measure and plot dissolved oxygen data. This data can be plotted to visually show oxygen concentrations throughout the basin.

The aeration basin is an area of critical importance in the operation of activated sludge treatment plants. Too often plants develop problems with systems that over-oxidize sludge, or fail to provide sufficient oxygen or mixing to the system. Many of these problems are a result of aeration equipment that cannot be adequately controlled. Activated sludge processes, however, demand that the operator have the ability to control aeration so that desirable dissolved oxygen levels and mixing patterns are achieved.

EQUIPMENT

D.O. Meter with 50 ft. lead with weighted mixing probe. (an alternative method is the winkler D.O. test which requires glassware and reagents).

Small boat, rubber inflatable or other stable craft.

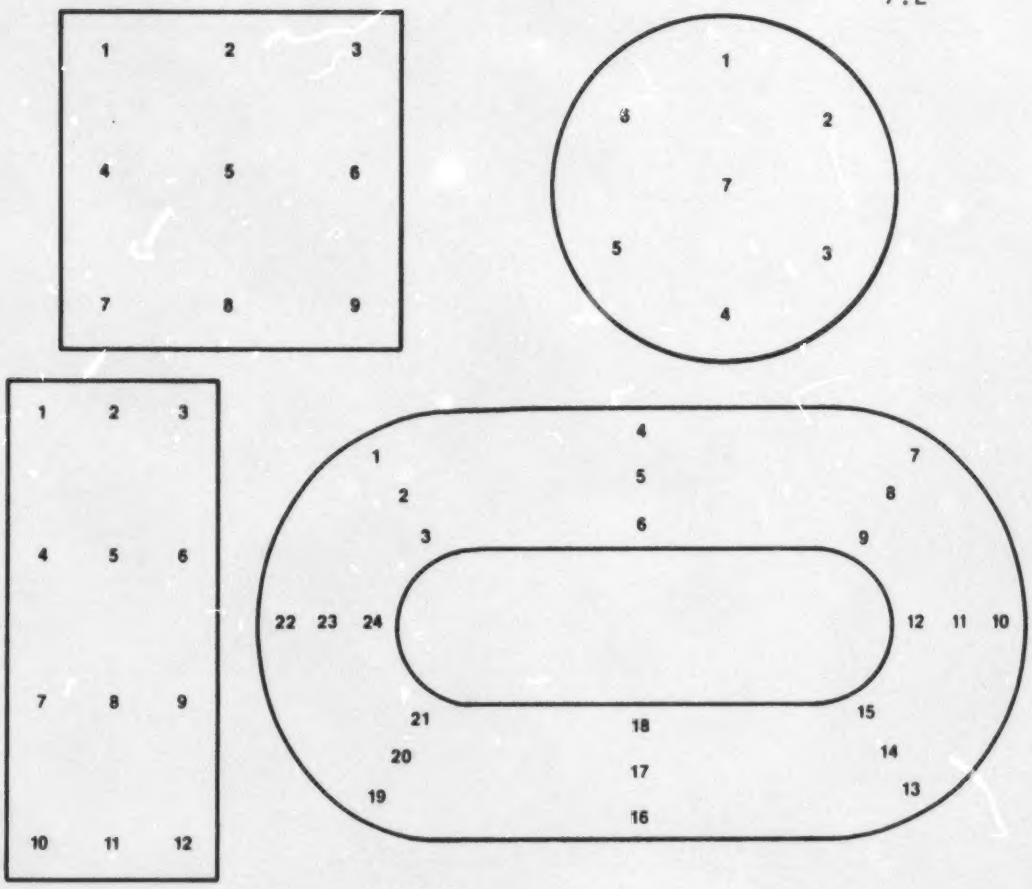
PROCEDURE

1. DETERMINE BASIN SHAPE

   The oxygen profile analysis is a sereis of dissolved oxygen determinations performed at preselected sample points in a basin. The first step in finding the sample points is based upon the shape of the basin.

2. SELECT SURFACE SITE

   Start by locating sites on the surface of the basin. Remember that the objective is to systematically cover the entire basin. Sites near the edge as well as the center should be established. One easy method of site selection is to consider the surface of the basin a regular geometric shape and divide it into sections. Each surface site can be numbered. Some examples of basin shapes are shown on the next page.



The immaginary lines connecting the sites are sometimes called transects. For example, in the square basin above the line with sites 2, 5, and 8 is one transect. In the circle, the line with sites 6, 7, and 3 is one transect.

3. IDENTIFY SAMPLING POINTS

Three or more sampling points are then located directly below each of the surface sample sites. Normally, three depths are selected--one point about one foot off the bottom, one near mid-depth, and one point just below the surface. The sample points can be identified by letters A, B and C.

4. POSITION D.O. METER OVER THE SURFACE SAMPLE SITE

Either a small boat or some sort of "clothes line" suspension system can be used. It is important to stay as close to the selected site as possible so that the data can be in-

terpreted correctly and so that the same position can be found for subsequent measurement.

5. MAKE D.O. READING

Use a D.O. probe with a long cord that has a weight to aid in submersion. The cord should be marked in feet to aid in depth positioning. Remember to properly calibrate the D.O. meter.

6. RECORD AND PLOT DATA

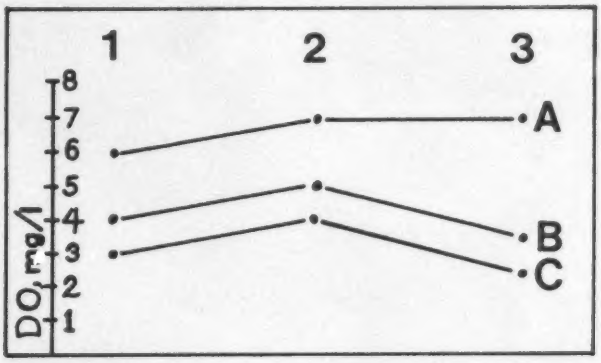
Many systems for recording and plotting data exist. Any method that provides a visual representation of D.O. conditions throughout the basin is okay.

One common method of plotting is to make a family of graphs; one for all of the sampling points below each site on a given transect.

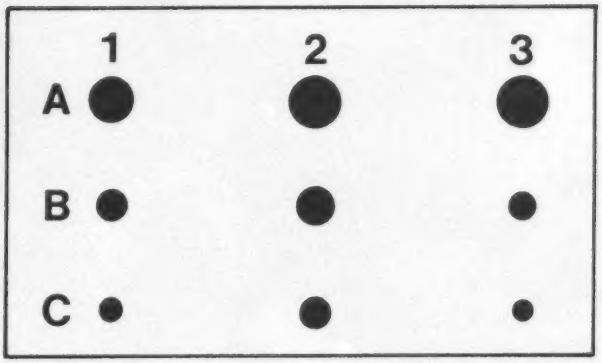
For example, in the square basin in Step 2 the following transect would result. The actual measured D.O. in mg/l could be written on the plot.

	1	2	3
A	6.0	7.0	7.0
B	4.0	5.0	3.5
C	3.0	4.0	2.5

The D.O. could be graphed with D.O. in mg/l on the vertical scale.



Circles representing the D.O. concentration could be drawn at each sample point on the transect.



7. INTERPRET RESULTS

Study of the plotted data may yield evidence of stratification, areas of no D.O. or simply uneven D.O. concentrations. Areas where insufficient D.O. is present to support biological growth may become apparent.

Corrective action may mean cleaning or repairing forced air headers or mechanical mixer, repositioning of aeration devices, installation of baffles, increasing forced air capacity or number of mixers, or simply adjusting the volume of air or speed of mixers.

Oxygen Profile Data

_____Location of Basin _____Date

_____Hour _____Air Temp.

_____Water Temp. _____Weather

_____Sampler's Name

SAMPLE SITE, DEPTH	SAMPLE POINTS O_2, mg/l								
	1	2	3	4	5	6	7	8	9
A									
B									
C									

SAMPLE DATA SHEET

Oxygen Profile Data

Supporting Data

A.B. #1 Location of Basin

10/4 Date

10:30a Hour

22 °C Air Temp.

12 °C Water Temp.

Cloudy Weather

James, M.L. Sampler's Name

Oxygen Concentration at Sample Point

SAMPLE SITE, DEPTH	SAMPLE POINTS O_2, mg/l								
	1	2	3	4	5	6	7	8	9
A	6.0	7.0	7.0						
B	4.0	5.0	3.5						
C	3.0	4.0	2.5						

NOTE: More than one data sheet may be needed if a large basin is being analyzed.

PROCEDURE SUMMARY

PROCEDURE

1. Study basin shape
2. Select surface sites
3. Identify sampling points
4. Position D.O. probe
5. Make D.O. reading
6. Record and plot

NO CALCULATIONS REQUIRED

Oxygen Profile Test

The above procedure summary is designed as a laboratory aid. It may be cut out and attached to a 5" X 7" index card for convient reference at the laboratory bench. To protect the card you may wish to cover it, front and back, with clear, self-adhesive shelf paper or similar clear material.

OXYGEN PROFILE TEST

WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. Most aquatic organisms use _____ as they convert food to stabilized end products.

   a)_____ nitrogen
   b)_____ carbon dioxide
   c)_____ dissolved oxygen
   d)_____ methane
   e)_____ hydrogen

2. If water lacks _____ the organisms and organic materials sink to the bottom of the basin.

   a)_____ carbon dioxide
   b)_____ turbulence
   c)_____ oxygen
   d)_____ organisms
   e)_____ solids

3. Aeration equipment in biological treatment systems provide _____.

   a)_____ organisms and solids
   b)_____ organics and inorganics
   c)_____ food and energy
   d)_____ oxygen and mixing
   e)_____ nitrogen and phosphates

4. In order to find out if appropriate DO concentrations exist in a basin an _____ is made.

   a)_____ MLVSS test
   b)_____ pH test
   c)_____ oxygen profile test
   d)_____ spin test
   e)_____ solids test

5. The oxygen profile analysis is a series of _____ measurements performed at preselected sample points in an aquatic system.

a)_____ pH tests
b)_____ solids tests
c)_____ spin tests
d)_____ CO_2 tests
e)_____ oxygen

6. Measurements are made throughout the basin near _____.

a)_____ the surface, middle and bottom
b)_____ the endline
c)_____ the aerators
d)_____ the cat walk
e)_____ the pumps

7. Equipment necessary for the oxygen profile analysis includes:

a)_____ DO meter with 50 foot lead
b)_____ pH meter and conductivity meter
c)_____ DO meter and centrifuge
d)_____ balance and burette
e)_____ thermometer and pH meter

8. The oxygen profile test includes four components. These components are:

a)_____ pH reading, centrifuge spin, sample collection, and alkalinity determination.
b)_____ establishment of sample points, making measurements, recording data, and plotting data.
c)_____ temperature measurements, pH measurements, conductivity measurements, calculations of raw data.
d)_____ sample collection, sample analysis, plotting of data, calculations.
e)_____ None of the above.

9. The most obvious application of the oxygen profile determination is to varify and locate the source of _____ problems in the basin.

a)_____ pH

b)_____ alkalinity

c)_____ solids concentration

d)_____ aeration

e)_____ temperature

10. The oxygen profile can be used as a tool to help adjust _____ to achieve the proper balance.

a)_____ pH

b)_____ temperature

c)_____ alkalinity

d)_____ CO_2

e)_____ aeration rate